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Keywords: COVID-19; Global value chains; Asia
JEL Classification: F15; F53

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Impacts of COVID-19 on Global Value Chains[§]

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Abstract: We investigate the impacts of COVID-19 on global value chains by examining bilateral trade in finished machinery products from January to June in both 2019 and 2020. We use the numbers of COVID-19 cases and deaths as measures of the impact of the pandemic. Specifically, we investigate how these impacts affect value chains in three scenarios—countries that import finished machinery products, countries that export finished machinery products, and countries that export machinery parts to countries exporting finished machinery products—to assess the impacts on demand, output, and supply-chain effects, respectively. In our analysis, the largest negative impacts were from supply-chain effects, followed by output effects. In contrast, we did not find significant impacts from demand effects. We also found that output effects are not so strong in intra-Asian trade compared with trade in other regions.

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1. Introduction

The ongoing coronavirus pandemic (hereinafter, COVID-19) has disrupted global value chains (GVCs). This disruption was observed worldwide from the outset of the pandemic because COVID-19 originated in China, the largest supplier of input materials in the world. The decrease and delay in materials exported from China resulted in decreases in production or changes of input sources in many countries. For example, according to an interview survey by the Japan External Trade Organization, a Mexican affiliate of a Japanese firm was forced to switch its input sources from China to South Korea. Moreover, the decrease or delay in exports from China decreased production in ASEAN countries, resulting in a reduction of their exports to Japan. According to a questionnaire survey by

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the Japan Institute of Logistics Systems, as a result of the difficulty importing goods from these countries, a Japanese firm switched its input source to domestic suppliers. In summary, the negative impacts of COVID-19 on production have been spread through GVCs.

This study examines the extent to which countries' exports of final goods were disrupted when COVID-19 began affecting the suppliers of inputs to these countries. Conceptually, a supplier country that is affected by the spread of COVID-19 will experience a drop in the production of inputs. The resulting decrease in the amount of exported inputs and their increased price raise importers' costs and reduce their productivity in final-good production. This, in turn, reduces the export of the final goods from the input-importing countries to other countries. Thus, the trade-reducing effect of COVID-19 is propagated throughout GVCs. We also consider the effects of COVID-19 on countries that export and import final goods. On the supply side, the decreased workforce and diminished productivity in exporting countries reduce the supply of final products. On the demand side, decreased earnings and lockdown measures reduce the demand for final products in importing countries. We take into account these direct effects of COVID-19 on trade.

We empirically investigate the impacts of COVID-19 on GVCs by examining bilateral trade in finished machinery products from January to June in both 2019 and 2020. Our dataset includes bilateral trade among 185 countries. To measure the prevalence of COVID-19, we use the numbers of COVID-19 cases and deaths collected by the European Centre for Disease Prevention and Control. Using these data, we investigate three country scenarios to capture pandemic-related economic damage to the GVC: (1) a country that imports finished machinery products, (2) a country that exports finished machinery products, and (3) a country that exports machinery parts to the country exporting finished machinery products. These three country scenarios capture demand, output, and supply chain impacts, respectively. We empirically investigate which of these effects (demand, output, and supply chain effects) has the largest impact on international trade during the COVID-19 pandemic period.

Our findings can be summarized as follows. First, COVID-19 did not have a significant effect on demand in importing countries, whereas the finished machinery trade is significantly hurt by higher rates of COVID-19 infection in countries exporting finished machinery products and countries exporting machinery parts to those countries. In short, the impacts of COVID-19 are primarily on the supply side, affecting both the outputs and inputs that play a crucial role in machinery trade; the impacts on demand play a less significant role. In particular, we found that the supply-chain effect has larger impacts on finished machinery trade compared with the output effect. The insignificant result in importing countries is consistent with the finding by Hayakawa and Mukunoki (2020), which found an insignificant effect on *total* world trade from the impacts of the pandemic on importing countries. Second, the output effect is not so strong when looking specifically

at intra-Asian trade. This result might be because some Asian countries exempt the machinery industry from workplace closure orders due to its importance in the economy.

The literature on GVCs is growing rapidly.[1] Among the many studies in this area, three studies have examined the impacts of COVID-19 on GVCs, as we do in this study. Inoue and Todo (2020) simulated the economic effect of a possible lockdown of Tokyo on production not only in Tokyo but also other in other parts of Japan, through supply chains. They demonstrated that were Tokyo to be locked down for a month, the indirect effect on other regions would be twice as large as the direct effect on Tokyo, leading to a total production loss of 5.3% of the annual GDP. A similar analysis was conducted for the UK by Pichler et al. (2020), which sheds light on input–output linkages across sectors. George et al. (2020) focused on the epidemiological dynamics, that is, the transmission of diseases across countries and industries, through supply chains. In summary, recent studies have performed simulation analyses on the effects on GVCs. In contrast, we examine these effects directly by using worldwide trade data collected during the COVID-19 pandemic.[2]

The remainder of this study is organized as follows. Section 2 theoretically discusses the possible effects of COVID-19 on GVCs. After explaining our empirical framework in Section 3, we report our estimation results in Section 4. Lastly, Section 5 presents the conclusion.

2. Conceptual Framework

In this section, we discuss the theoretical background on how COVID-19 affects the trade of machinery goods when exporters procure inputs through GVCs. An exporting country and an importing country of finished machinery products are denoted by country *i* and country *j*, respectively. The prevalence of COVID-19 in country *i* and in country *j* affect trade between them. Impacts from COVID-19 in countries that supply inputs to country *i* also have an influence on trade. Let country *k* denote a third country exporting inputs used for the production of the finished machinery products in country *i*. We summarize the trade effects of COVID-19 in these countries separately.

Let us start by theoretically examining the impacts of COVID-19 in exporting countries. An increase in the number of COVID-19 cases/deaths in country *i* reduces the supply of goods because the COVID-19 infections and deaths reduce labor participation. In addition, lockdown measures and the resulting decrease in mobility within workplaces

[1] Murakami and Otsuka (2020) presents an excellent review of existing studies in GVCs.

[2] Fuchs et al. (2020) also examined the trade impacts of COVID-19 by using export data from China. Specifically, they empirically investigate whether previous economic linkages established through trade and investment as well as political relations are associated with the China's export pattern of critical medical goods.

further decrease productivity, unless remote work is sufficiently effective to maintain production activities. Given that the production of finished machinery products is relatively difficult to do at home or other remote location, COVID-19 would decrease the production of outputs. For instance, Dingel and Neiman (2020) have estimated that the share of jobs that can be done at home is 22% in the manufacturing sector. A decrease in outputs, ceteris paribus, reduces exports of these products. We call this negative effect on trade *the output effect*. One countervailing effect is that finished machinery products might be exported more frequently, rather than supplied domestically, if domestic demand also decreases in the exporting country. Thus, although the net effect on trade in exporting countries is not straightforward, the impact of COVID-19 is expected to decrease exports if the output effect is sufficiently large.

Next, we discuss the impacts of COVID-19 on importing countries. Higher rates of COVID-19 in country *j* can decrease workers' earnings in that country due to the decrease in work hours or the loss of jobs due to lockdown measures. Decreased earnings directly reduce the aggregate demand of the country. For instance, Bekaert et al. (2020) calculated that a decline in real GDP growth in the United States in the first quarter of 2020 was due mainly to an aggregate demand shock. Lockdown measures also decrease demand for products by restricting people's mobility and access to the retail market. These demand shocks have negative impacts on trade. COVID-19 may also reduce trade by changing the composition of demands. Although the demands for some essential products such as medical supplies and food may increase, the demands for finished machinery products are likely to decrease because they are durable goods that are not purchased on a daily basis. Eaton et al. (2016) suggest that spending on durable goods decreases more than that on non-durable goods when a country is hit by negative demand shocks. Carvalho et al. (2020) used individual transaction-level data from Spain to show that the COVID-19 lockdown measures there decreased the market share of durables such as automobiles, computers, and furniture, while the market share of food increased. The demand shift from durable to non-durable goods has a negative effect on the imports of finished machinery products. We sum up these negative effects on trade as *the demand effect*.[3]

In addition to the direct effects on importing and exporting countries, COVID-19 impacts in country *k*, which supplies the inputs to country *i* that are used to produce finished machinery products, may reduce trade from country *i* to country *j* through GVCs. A disruption in input production in country *k* caused by COVID-19 decreases the volume of

[3] Because the domestic supplies of finished machinery products in the importing countries also decrease with the spread of COVID-19, it is ambiguous whether import demand decreases. However, it is natural to suppose that the demand effect outweighs the output effect because people usually do not need to purchase these goods during a pandemic such as COVID-19; therefore, total demand for finished machinery products can be assumed to decrease.

inputs supplied to country *i*. It also increases the price of those inputs.[4] The resulting increase in input costs raises the production cost and decreases the productivity of the exporters in country *i*, as is suggested by Halpern et al. (2015). Blaum et al. (2018) also show that increased input costs raise the prices of final products, thereby reducing their demand. These effects through the output–input linkage will reduce the output and export of final products. Indeed, Barrot and Sauvagnat (2016) show that, if suppliers are hit by a natural disaster, their customers experience a substantial drop in the sales of their products. Boehm et al. (2019) show that US firms that relied on Japanese inputs experienced large drops in production after the 2011 earthquake in Japan. Acemoglu and Tahbaz-Salehi (2020) theoretically investigate how disruptions to supply chains magnify negative shocks. We denote the negative effect on trade of downstream products caused by a negative supply shock in the supplier countries of upstream inputs as *the supply-chain effect*.

3. Empirical Framework

This section presents our empirical framework for investigating the impacts of COVID-19 on GVCs. Our simple model is as follows.

$$Trade_{ijt} = \exp\{\alpha_1 RTA_{ijt} + \alpha_2 \ln GDP_{it} + \alpha_3 \ln GDP_{jt} + \alpha_4 COVID_{it} + \alpha_5 COVID_{jt} + \alpha_6 SCOVID_{it} + \delta_{ij} + \delta_t\} + \epsilon_{ijt} \quad (1)$$

$Trade_{ijt}$ is the export value of finished machinery products from countries *i* to *j* in time *t*. As a time-variant country-pair element, we introduce a regional trade agreement (RTA) dummy variable that takes a value of one if the two countries are members of the same RTA, and a value of zero otherwise (RTA_{ijt}). The time-variant exporter/importer characteristics include the respective country's logged GDP ($\ln GDP_{it}$ and $\ln GDP_{jt}$). In this study, we furthermore assume that time-variant exporter/importer characteristics include the extent of the damage of COVID-19 in three countries (called *COVID* variables), including for the importing country ($COVID_{jt}$), the exporting country ($COVID_{it}$), and countries exporting machinery parts to country *i* ($SCOVID_{it}$). δ_{ij} is the country-pair fixed effects, which control for the time-invariant country pair characteristics such as the geographical distance between the two countries. Macro shocks are captured by year fixed effects, δ_t. ϵ_{ijt} is a disturbance term.

Our data sources are as follows. The study examines data from two time periods—January to June in 2019 and January to June in 2020. We obtain monthly data on both exports and imports of finished machinery products in reporting countries from the Global Trade

[4] If a third country exporting the finished machinery products is affected by COVID-19, exports from country *i* may increase due to a substitution effect. Hayakawa and Mukunoki (2020) confirmed that the spread of COVID-19 in an exporter's neighboring countries has a positive effect on exports.

Atlas maintained by IHS Markit.[5] The export values are included in the dataset after multiplying 1.05 to roughly adjust for freight and insurance charges. The 26 reporting countries and their 185 partner countries in our dataset are listed in Appendix A. Machinery products are defined as those in general machinery (HS84), electric machinery (HS85), transport equipment (HS86-89), and precision machinery sectors (HS90-92). Kimura and Obashi (2010) carefully classify HS six-digit codes in these industries into finished products and intermediate products. By using this list, we restrict the study products only to the HS codes that are categorized into finished products and aggregate their exports at a country-pair level.

As mentioned in Section 1, we use the numbers of COVID-19 cases and deaths as measures of the impact of the pandemic, with data obtained from the European Centre for Disease Prevention and Control.[6] These data were collected on a daily basis from reports from health authorities worldwide. We use the total number of cases and deaths from January to June in 2020.[7] The numbers are set to zero for the same January to June period in 2019. Although we use both the numbers of cases and deaths, these two kinds of numbers are not necessarily perfectly correlated because the mortality rate differs widely across countries. Nevertheless, an increase in either number induces the government to implement measures to suppress transmission, which has an effect on people (e.g., stay-at-home orders) and companies (e.g., workplace closure orders). Furthermore, the strictness of such policies (e.g., recommended vs. required) also differs depending on the number of cases and deaths. Thus, to obtain robust results, we model using both numbers.[8]

Specifically, our *COVID* variables are constructed as follows. $COVID_{it}$ and $COVID_{jt}$ are the number of cases/deaths in an exporting country and an importing country, respectively. As mentioned above, $SCOVID_{it}$ captures the extent of COVID-19 impacts in countries supplying machinery parts to the export country, country i. $SCOVID_{it}$ is calculated as the weighted average of the number of cases/deaths among those suppliers to country i. Specifically, this variable is constructed as follows:

$$SCOVID_{it} = \sum\nolimits_k \left[\left(\frac{Parts_{ki2019}}{\sum_l Parts_{li2019}} \right) \times COVID_{kt} \right].$$

We use the share of imports of machinery parts from each country from January to June in 2019 (i.e., the pre-COVID-19 period) out of the total imports of machinery parts as weights. As in our dependent variable, data on imports of machinery parts are obtained from the Global Trade Atlas. We add a value of one to these three variables and then take their logs.

[5] https://connect.ihsmarkit.com/gta/home

[6] https://data.europa.eu/euodp/en/data/dataset/covid-19-coronavirus-data

[7] Note that the database reports 27 cases for China on 31 December 2019; we added these cases to our 2020 variable for China.

[8] The use of the ratio of cases and deaths to total population does not change our results much because we control for country-pair fixed effects.

The data sources for other variables are as follows. We obtain the data on GDP from the World Economic Outlook by the IMF. We use 2018 GDP figures for January–June 2019, and 2019 for January–June 2020 because GDP for 2020 has not yet been realized.[9] Also, we intend to avoid GDP variables from containing the impacts of COVID-19 because we capture those impacts solely by our *COVID* variables. Because we focus on the trade in the first half of each year, we can interpret our inclusion of GDP in the previous year as controlling for the demand/production conditions just before the first half each year. We obtain the RTA dummy variable from Egger and Larch (2008) and its 2020 update by using the RTA information available on the website of the World Trade Organization.[10] We estimate our equation by the Poisson pseudo maximum likelihood (PPML) method. The basic statistics are reported in Table 1.

=== Table 1 ===

Before reporting our estimation results, we provide an overview of COVID-19 impacts and data on machinery exports in the world. Figure 1 depicts the daily numbers of COVID-19 cases and deaths in the world. In March, both the cases and deaths increased exponentially. Therefore, in April, to slow the spread of the coronavirus, many countries imposed some form of restriction on people and businesses. Several countries declared citywide or nationwide lockdowns. Also, many countries imposed an entry ban on foreign travelers. As a result, the magnitude of increase in cases and deaths became constant in April. Afterward, however, the numbers of cases and deaths show different movements. Although the former again started to increase considerably, the latter gradually decreased. That is, we observe a dramatic decline in mortality rates.

=== Figure 1 ===

Figure 2 shows the change in world machinery trade in 2020 relative to that in 2019. In January, trade in both finished goods and parts was slightly smaller in 2020 compared with that in 2019. However, in February, it returned to the level of the previous year. As shown in Figure 1, COVID-19 spread across the globe in March. Consequently, the machinery trade started to dramatically decrease around the world starting in March. This decrease was larger for trade in finished machinery goods than for trade in machinery parts. In May 2020, trade in finished machinery goods and machinery parts were respectively more than 30% and 20% lower compared with 2019 levels. However, machinery trade

[9] GDP is shown in billions of U.S. dollars.

[10] In 2020, the following RTAs came into effect: European Union–Singapore, Eurasian Economic Union–Iran, Chile–Indonesia, Hong Kong–Georgia, Peru–Australia, and Hong Kong–Australia.

started to recover in June, perhaps because most of the countries gradually started to lift lockdown policies.

=== Figure 2 ===

Based on the outsized role of Asian countries as the world's supplier of machinery products, we examine changes in intra-Asian trade in machinery industries. In this paper, we define Asia as the 16 countries that have negotiated the regional comprehensive economic partnership, namely the 10 ASEAN countries as well as Australia, China, India, Japan, South Korea, and New Zealand. It is well known that these countries have developed sophisticated international production networks. The results are depicted in Figure 3, which shows a slightly different change from Figure 2. The trade of machinery parts in Asia shows a similar trend to that in the world average. Machinery parts trade started to decrease, particularly in April, and to recover in June. In contrast, the trade of finished machinery goods has remained at a low but relatively stable level compared with that in 2019, though it decreased considerably in May. Nevertheless, the magnitude of the decrease in machinery trade is smaller in the intra-Asian trade than in the world average.

=== Figure 3 ===

4. Empirical Results

This section reports our estimation results. We cluster standard errors by country pairs. Table 2 shows our baseline results.[11] In this table, we introduce our *COVID* variables one-by-one. The RTA dummy variable and importer's GDP have insignificant coefficients, whereas the coefficients for exporter's GDP are significantly positive. Among the *COVID* variables, importer country has a significant effect only when being evaluated by the number of deaths. In contrast, both the number of cases and deaths in exporting countries have significantly negative effects on finished machinery trade. Thus, decreases in workforce size and productivity in exporting countries result in decreased trade. These results are consistent with those obtained for total trade in Hayakawa and Mukunoki (2020). Another noteworthy result is that suppliers' damages, especially in terms of the number of deaths, have a significantly negative effect on trade. In sum, these results imply that the impacts on the supply side, in terms of both outputs and inputs, play a crucial role in machinery trade, rather than affecting trade on the demand side.

[11] Some singleton observations are dropped due to our inclusion of fixed effects.

=== Table 2 ===

Next, in columns (I) and (II) in Table 3, we introduce our *COVID* variables. The results are qualitatively similar to those in Table 2. Although the demand effect is insignificant for both the cases and deaths, the output and supply-chain effects are significantly negative. The average logged-numbers of importing country deaths, exporting country deaths, and supplier country deaths in 2020 are 4.46, 7.24, and 9.92, respectively.[12] Thus, using the estimates in column (II), we can see that importing country deaths, exporting country deaths, and supplier country deaths decrease trade by 0.5%, 22%, and 64%, respectively. Thus, on average, the largest negative impact on trade can be found in the supply-chain effect, followed by the output effect. Such a large contribution of the supply-chain effect implies that firms did not have sufficient inventory of inputs. In the remaining columns, we account for the gap in months between shipments and contracts to some extent. Specifically, in columns (III) and (IV), we replace the dependent variable with the trade values only in June, and we replace the variables for COVID-19 with those from January to May in columns (V) and (VI).[13] The results of the *COVID* variables in both robustness checks show similar results to those in columns (I) and (II).[14]

=== Table 3 ===

In Figure 3, we found a slightly different trend for machinery trade in Asia, compared with the world average. To investigate differences in the effects of COVID-19 on trade, we introduce the interaction terms of our *COVID* variables with an Asian dummy (*Asia*), which takes a value of one for intra-Asian trade. The results are reported in Table 4. Like in Table 3, we examine the dependent variable and *COVID* variables measured by different time periods. Non-interacted *COVID* variables have similar results to those in Table 3. Although the coefficients for importing country impacts are insignificant, exporting and supplier country cases and deaths have significantly negative coefficients. The coefficients for the

[12] The non-logged numbers are 85, 1,397, and 20,246, respectively. Because exporting countries (i.e., reporting countries in the Global Trade Atlas) include many European countries and the U.S., the average number of exporting country deaths becomes larger than that of importing country deaths. Also, many countries import machinery parts from the U.S., where the number of deaths as of the end of June is more than 130,000. This yields a rather large number of supplier country deaths.

[13] One may suggest differentiating between the flow and stock of COVID-19 burden. We avoid this issue by examining the trade aggregated over time, i.e., examining only one time point in each year. We leave this issue for future analysis with a longer study period.

[14] Another robustness check is in Appendix B. To take logs, we added a value of one to the *COVID* variables. Our results do not qualitatively change even if adding a very small number other than one.

interaction terms with the Asian dummy are significant only in the case of exporters.[15] The coefficients for the interaction terms between exporting country impacts and the Asian dummy are estimated to be significantly positive, indicating that exporting country COVID cases and deaths do not have strong negative effects on the intra-Asian trade of finished machinery products. From a quantitative viewpoint, column (II) indicates that exporting country deaths and supplier country deaths decrease intra-Asian trade by 2% and 75%, respectively.

=== Table 4 ===

It is worth discussing these results on the interaction terms. The insignificant results in the interaction with supplier country impacts may be because firms in Asia tend to use just-in-time production systems in machinery industries. Thus, because they do not have enough inventory for machinery parts, COVID impacts in supplier countries negatively affect the exports of finished machinery products, as in the case of other regions. In contrast, the non-negative impact of COVID-19 in exporting country on intra-Asian trade might be because firms in Asia kept some amount of finished machinery products in their inventories. That is, their inventory adjustment may enable manufacturing firms in Asia to continue to export, even when their production operations are decreased or delayed. Indeed, according to questionnaire surveys conducted by JETRO and some organizations in Malaysia, Indonesia, and the Philippines, many Japanese manufacturing firms reacted to workplace closure orders by adjusting the amount of final products held in their inventories.

Another important reason for the non-negative effect of COVID-19 impacts in exporting countries involved in intra-Asian trade is that factory operations were often exempt from lockdown and workplace closure orders. In many countries, factory operations were banned by workplace closure orders. In Asian countries, however, some industries were permitted to operate if adequate infection control measures (e.g., social distancing) were taken. Typically, the industries allowed to continue operating are those that produce essential products, such as medical supplies and equipment and food products. Some countries also allow operations to continue in export-oriented companies, firms in Special Economic Zones, or industries that require production to maintain the supply chain. Permission for these industries to operate can be found in some Asian countries, including China, India, Malaysia, and the Philippines. Given that such exemptions generally apply to the machinery industry, the negative effects of COVID-19 on exporting countries involved in machinery trade may have been mitigated.

[15] These results do not change even if we exclude China from the exporting and importing country variables, or if we exclude the RTA dummy and the GDP variables.

5. Concluding Remarks

This paper investigates the supply-chain effect of COVID-19 on trade by using monthly trade data of finished machinery products. Although there have been some simulation analyses examining the impacts of COVID-19 on GVCs, this is the first paper to use observed trade data to examine how the COVID-19 pandemic disrupted trade of final goods through input–output linkage.

Our empirical findings indicate that exports of final goods decrease if an exporting country imports inputs from countries affected more seriously by COVID-19. We have also confirmed that COVID-19 impacts on exporting countries have a significantly negative effect on their exports. From a quantitative viewpoint, the former supply-chain effect was found to be larger than the latter output effect. In contrast, the COVID-19 impacts in importing countries do not have significant effects on trade. These results indicate that both the output effect and the supply-chain effect play a key role in identifying the impacts of COVID-19 on trade in a world with increasing connectedness through GVCs.

We also find that the negative effects of COVID-19 on exporting countries are smaller in intra-Asian trade. This result is perhaps because some Asian countries permit the machinery industry to operate even when workplace closure orders are in effect or because manufacturing firms in Asia can mitigate the negative supply chain shocks by adjusting their existing inventory of finished goods. In short, our results suggest that addressing the supply-chain effect is most important for ameliorating the impacts of the COVID-19 pandemic on trade. We hope this paper sheds new light on how to confront these challenges.

References

Acemoglu, Daron and Alireza Tahbaz-Salehi, 2020. Firms, Failures, and Fluctuations: The Macroeconomics of Supply Chain Disruptions, CEPR DP15074

Barrot, Jean-Noël and Julien Sauvagnatm 2016. Input Specificity and the Propagation of Idiosyncratic Shocks in Production Networks, *The Quarterly Journal of Economics*, 131(3): 1543-1592.

Bekaert, Geert, Eric Engstrom, and Andrey Ermolov, 2020. Aggregate Demand and Aggregate Supply Effects of COVID-19: A Real-time Analysis, *Covid Economics*, 25: 141-168.

Blaum, Joaquin, Claire Lelarge, and Michael Peters, 2018, The Gains from Input Trade with Heterogeneous Importers, *American Economic Journal: Macroeconomics*, 10(4): 77-127.

Boehm, Christoph E., Aaron Flaaen, and Nitya Pandalai-Nayar, 2019, Input Linkages and the Transmission of Shocks: Firm-level Evidence from the 2011 Tōhoku Earthquake, *Review of Economics and Statistics*, 101(1): 60-75.

Carvalho, Vasco, Juan Ramón García, Stephen Hansen, Alvaro Ortiz, Tomasa Rodrigo, José V. Rodríguez Mora, and Pep Ruiz, 2020. Tracking the Covid-19 Crisis with High-Resolution Transaction Data, CEPR DP14642.

Dingel, Jonathan I. and Brent Neiman, 2020, How Many Jobs Can Be Done at Home?, *Journal of Public Economics*, 189: 104235.

Eaton, Jonathan, Samuel Kortum, Brent Neiman, and John Romalis, 2016, Trade and the Global Recession, *American Economic Review*, 106(11): 3401-38.

Egger, Peter and Larch, Mario, 2008, Interdependent Preferential Trade Agreement Memberships: An Empirical Analysis, *Journal of International Economics*, 76(2): 384-399.

Fuchs, Andreas, Lennart Kaplan, Krisztina Kis-Katos, Sebastian S. Schmidt, Felix Turbanisch, and Feicheng Wang, 2020, Mask Wars: China's exports of medical goods in times of COVID-19, *Covid Economics*, 42: 26-64.

George, Ammu, Changtai Li, Jing Zhi Lim, and Taojun Xie, 2020, Propagation of Epidemics' Economic Impacts via Production Networks: The Cases of China and ASEAN during SARS and COVID-19, *Covid Economics*, 37: 27-56.

Halpern, László, Miklós Koren, and Adam Szeidl, 2015, Imported Inputs and Productivity, *American Economic Review*, 105(12): 3660-3703.

Hayakawa, Kazunobu and Hiroshi Mukunoki, 2020, Impacts of COVID-19 on International Trade: Evidence from the First Quarter of 2020, IDE Discussion Papers No.791.

Inoue, Hiroyasu and Yasuyuki Todo, 2020, The Propagation of the Economic Impact through Supply Chains: The Case of a Mega-city Lockdown to Contain the Spread of Covid-19, *Covid Economics*, 2: 43-59.

Kimura, Fukunari and Ayako Obashi, 2010, International Production Networks in Machinery Industries: Structure and Its Evolution, Working Papers DP-2010-09, Economic Research Institute for ASEAN and East Asia (ERIA).

Murakami, Yoshimichi and Keijiro Otsuka 2020, Governance, Information Spillovers, and Productivity of Local Firms: Toward an Integrated Approach to Foreign Direct Investment and Global Value Chains, *The Developing Economies*, 58(2): 134-174.

Pichler, Anton, Marco Pangallo, R. Maria del Rio-Chanona, François Lafond, and J. Doyne Farmer, 2020, Production Networks and Epidemic Spreading: How to Restart the UK Economy?, *Covid Economics*, 23: 79-151.

Table 1. Basic Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
RTA dummy	8,382	0.325	0.468	0	1
ln Importer's GDP	8,382	3.886	2.302	-3.170	9.973
ln Exporter's GDP	8,382	7.046	1.283	3.762	9.973
ln (1+Importer's cases)	8,382	3.993	4.577	0	14.767
ln (1+Exporter's cases)	8,382	5.224	5.621	0	14.767
ln (1+Supplier's cases)	8,382	6.380	6.394	0	14.390
ln (1+Importer's deaths)	8,382	2.229	3.037	0	11.745
ln (1+Exporter's deaths)	8,382	3.621	4.175	0	11.745
ln (1+Supplier's deaths)	8,382	4.958	4.972	0	11.372

Sources: Authors' computation.

Table 2. Baseline Estimation Results

	(I)	(II)	(III)	(IV)	(V)	(VI)
RTA dummy	0.099	0.088	0.094	0.023	0.113	0.116
	[0.148]	[0.153]	[0.142]	[0.119]	[0.150]	[0.150]
ln Importer's GDP	-0.284	-0.277	-0.446	-0.523**	-0.18	-0.133
	[0.290]	[0.286]	[0.272]	[0.259]	[0.291]	[0.284]
ln Exporter's GDP	1.926***	1.910***	2.017***	2.090***	1.685***	1.439***
	[0.398]	[0.396]	[0.357]	[0.333]	[0.386]	[0.388]
ln (1+Importer's cases)	-0.004					
	[0.004]					
ln (1+Importer's deaths)		-0.006*				
		[0.004]				
ln (1+Exporter's cases)			-0.027***			
			[0.006]			
ln (1+Exporter's deaths)				-0.034***		
				[0.005]		
ln (1+Supplier's cases)					-0.049**	
					[0.020]	
ln (1+Supplier's deaths)						-0.089***
						[0.018]
Number of observations	8,382	8,382	8,382	8,382	8,382	8,382
Log pseudolikelihood	-2E+10	-2E+10	-2E+10	-2E+10	-2E+10	-2E+10

Notes: This table reports the estimation results by the PPML method. ***, **, and * indicate 1%, 5%, and 10% levels of statistical significance, respectively. The standard errors reported in parentheses are those clustered by country pairs. In all specifications, we control for country-pair fixed effects and time fixed effects.

Table 3. Robustness Checks

	(I)	(II)	(III)	(IV)	(V)	(VI)
RTA dummy	0.107	0.038	0.159	0.045	0.107	0.038
	[0.144]	[0.124]	[0.416]	[0.370]	[0.143]	[0.122]
ln Importer's GDP	-0.301	-0.371	-0.547	-0.623	-0.301	-0.382
	[0.258]	[0.247]	[0.510]	[0.457]	[0.260]	[0.249]
ln Exporter's GDP	1.715***	1.701***	3.532***	2.935***	1.643***	1.604***
	[0.349]	[0.348]	[0.810]	[0.672]	[0.350]	[0.343]
ln (1+Importer's cases)	-0.001		-0.005		0.000	
	[0.003]		[0.008]		[0.004]	
ln (1+Exporter's cases)	-0.029***		-0.064***		-0.029***	
	[0.006]		[0.013]		[0.006]	
ln (1+Supplier's cases)	-0.056***		-0.233***		-0.063***	
	[0.016]		[0.058]		[0.017]	
ln (1+Importer's deaths)		-0.001		-0.002		-0.001
		[0.004]		[0.007]		[0.004]
ln (1+Exporter's deaths)		-0.031***		-0.059***		-0.032***
		[0.006]		[0.012]		[0.006]
ln (1+Supplier's deaths)		-0.065***		-0.328***		-0.072***
		[0.022]		[0.046]		[0.020]
Trade period	Jan-Jun	Jan-Jun	Jun	Jun	Jan-Jun	Jan-Jun
Covid period	Jan-Jun	Jan-Jun	Jan-Jun	Jan-Jun	Jan-May	Jan-May
Number of observations	8,382	8,382	7,662	7,662	8,382	8,382
Log pseudolikelihood	-2E+10	-2E+10	-1E+10	-1E+10	-2E+10	-2E+10

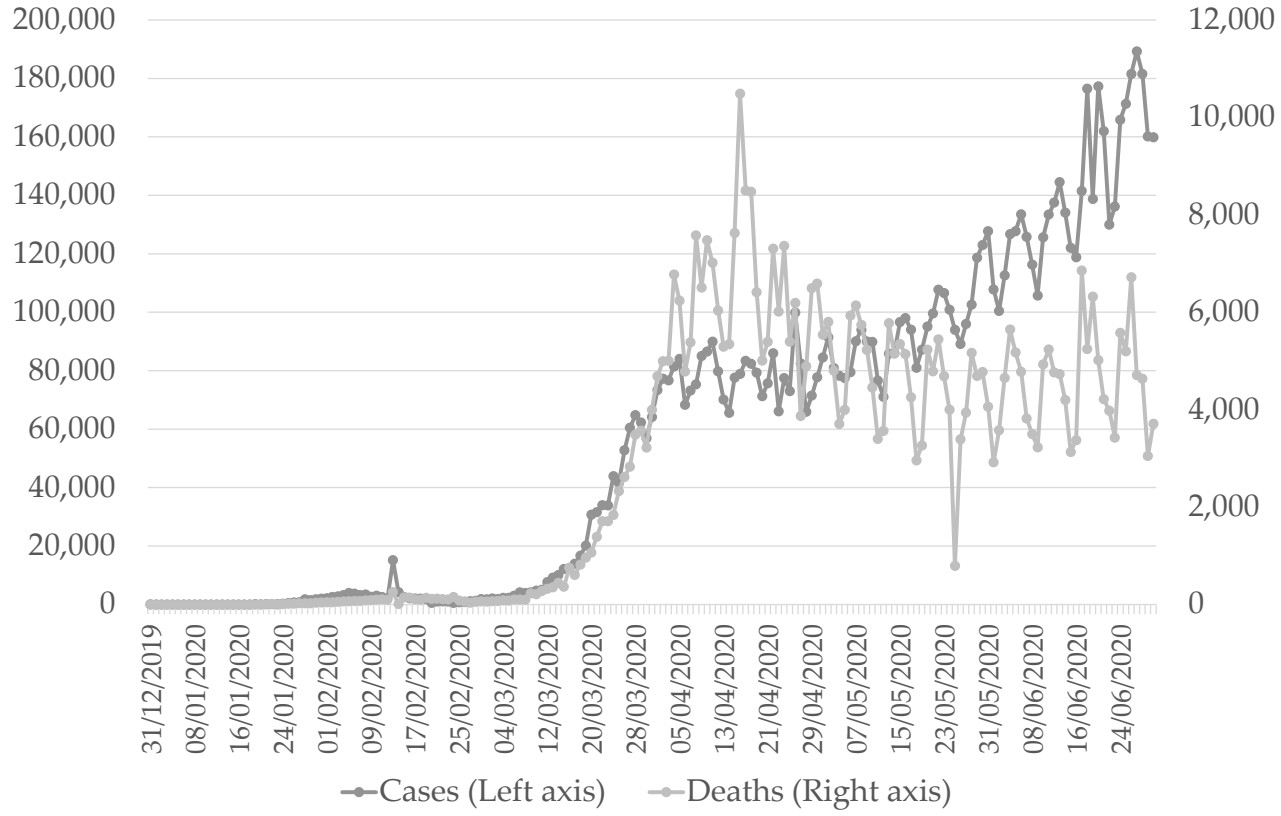
Notes: This table reports the estimation results by the PPML method. ***, **, and * indicate 1%, 5%, and 10% levels of statistical significance, respectively. The standard errors reported in parentheses are those clustered by country pairs. In all specifications, we control for country-pair fixed effects and time fixed effects.

Table 4. Asia Effects

	(I)	(II)	(III)	(IV)	(V)	(VI)
RTA dummy	0.109	0.036	0.16	0.033	0.109	0.035
	[0.145]	[0.123]	[0.417]	[0.368]	[0.144]	[0.121]
ln Importer's GDP	-0.369	-0.404*	-0.615	-0.639	-0.374	-0.419*
	[0.250]	[0.242]	[0.522]	[0.459]	[0.252]	[0.243]
ln Exporter's GDP	1.560***	1.573***	3.209***	2.740***	1.479***	1.458***
	[0.353]	[0.352]	[0.854]	[0.693]	[0.354]	[0.347]
ln (1+Importer's cases)	0.001		-0.003		0.001	
	[0.003]		[0.010]		[0.004]	
ln (1+Importer's cases) * Asia	-0.005		-0.009		0.004	
	[0.013]		[0.025]		[0.015]	
ln (1+Exporter's cases)	-0.028***		-0.065***		-0.029***	
	[0.006]		[0.013]		[0.007]	
ln (1+Exporter's cases) * Asia	0.030		0.089*		0.033	
	[0.023]		[0.049]		[0.022]	
ln (1+Supplier's cases)	-0.054***		-0.229***		-0.061***	
	[0.016]		[0.058]		[0.017]	
ln (1+Supplier's cases) * Asia	-0.016		-0.06		-0.025	
	[0.022]		[0.047]		[0.021]	
ln (1+Importer's deaths)		0.000		-0.001		0.000
		[0.004]		[0.008]		[0.004]
ln (1+Importer's deaths) * Asia		0.000		0.001		0.004
		[0.011]		[0.020]		[0.011]
ln (1+Exporter's deaths)		-0.032***		-0.063***		-0.034***
		[0.006]		[0.012]		[0.006]
ln (1+Exporter's deaths) * Asia		0.029**		0.056*		0.031**
		[0.014]		[0.030]		[0.014]
ln (1+Supplier's deaths)		-0.060***		-0.318***		-0.068***
		[0.022]		[0.048]		[0.020]
ln (1+Supplier's deaths) * Asia		-0.017		-0.039		-0.021
		[0.013]		[0.028]		[0.013]
Trade period	Jan-Jun	Jan-Jun	Jun	Jun	Jan-Jun	Jan-Jun
Covid period	Jan-Jun	Jan-Jun	Jan-Jun	Jan-Jun	Jan-May	Jan-May
Number of observations	8,382	8,382	7,662	7,662	8,382	8,382
Log pseudolikelihood	-2E+10	-2E+10	-1E+10	-1E+10	-2E+10	-2E+10

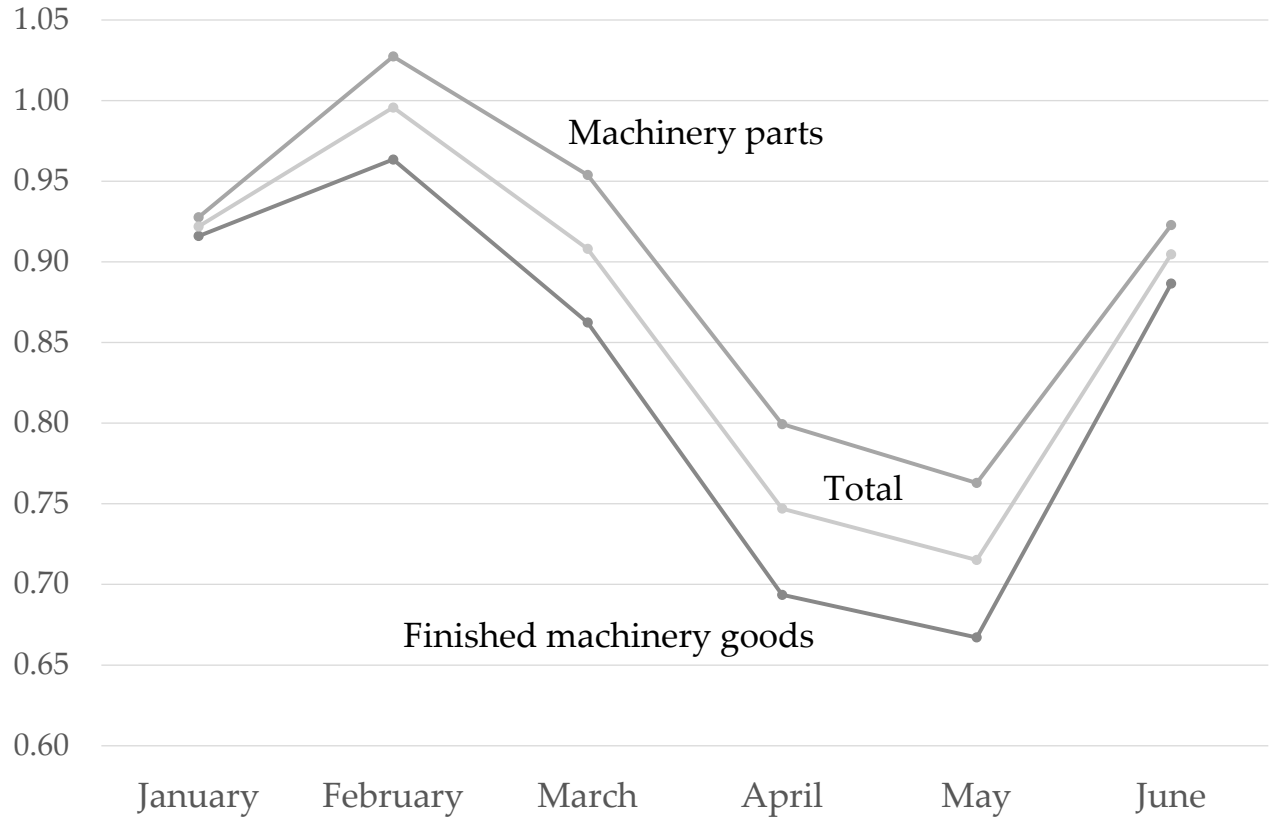
Notes: This table reports the estimation results by the PPML method. ***, **, and * indicate 1%, 5%, and 10% levels of statistical significance, respectively. The standard errors reported in parentheses are those clustered by country pairs. In all specifications, we control for country-pair fixed effects and time fixed effects.

Figure 1. The Daily Numbers of COVID-19 Cases and Deaths in the World



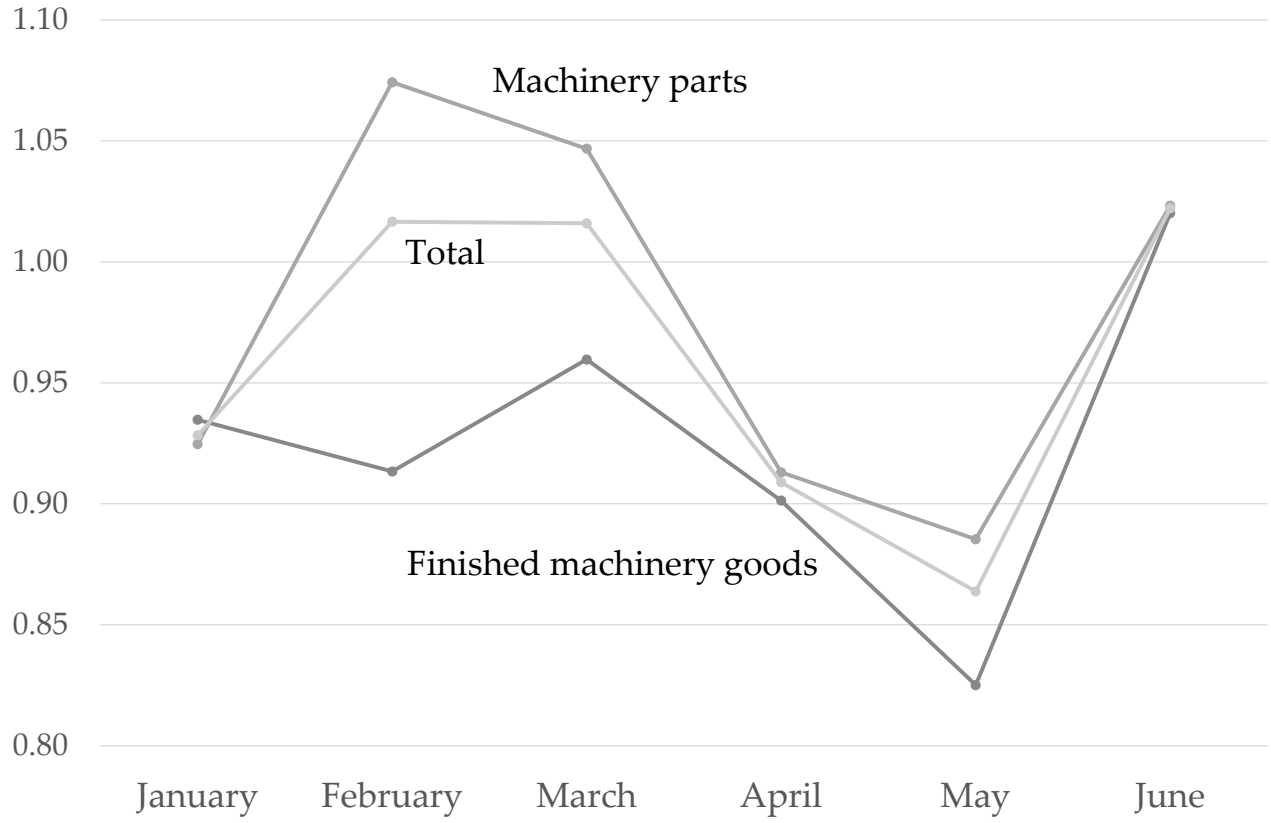
Source: European Centre for Disease Prevention and Control.

Figure 2. Global Trade in 2020 Relative to Trade in 2019



Source: Authors' compilation.

Figure 3. Intra-Asian Trade in 2020 Relative to Trade in 2019



Source: Authors' compilation.

Appendix A. Study Countries

26 Reporting Countries (ISO 2-letter codes):

AR, AU, BR, CA, CH, CI, CN, DE, ES, FR, GB, GR, HK, ID, IE, JP, KR, MX, PH, PT, RU, SG, TH, TW, US, ZA

185 Partner Countries (ISO 2-letter codes):

AE, AF, AG, AL, AM, AO, AR, AT, AU, AW, AZ, BA, BB, BD, BE, BF, BG, BH, BI, BJ, BN, BO, BR, BS, BT, BW, BY, BZ, CA, CF, CG, CH, CI, CL, CM, CN, CO, CR, CV, CY, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ER, ES, ET, FI, FJ, FM, FR, GA, GB, GD, GE, GH, GM, GN, GQ, GR, GT, GW, GY, HK, HN, HR, HT, HU, ID, IE, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KI, KM, KN, KR, KW, KZ, LA, LB, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MH, ML, MM, MN, MO, MR, MT, MU, MV, MW, MX, MY, MZ, NA, NE, NG, NI, NL, NO, NP, NR, NZ, OM, PA, PE, PG, PH, PK, PL, PR, PT, PW, PY, QA, RO, RU, RW, SA, SB, SC, SD, SE, SG, SI, SK, SL, SM, SN, SO, SR, ST, SV, TD, TG, TH, TJ, TM, TN, TO, TR, TT, TV, TW, TZ, UA, UG, US, UY, UZ, VC, VE, VN, VU, WS, YE, ZA, ZM, ZW

Appendix B. Other Estimation Results.

Table B. Adding a Small Number to COVID-19 Variables

	(I)	(II)	(III)	(IV)	(V)	(VI)
RTA dummy	0.109	0.08	0.162	0.122	0.109	0.079
	[0.147]	[0.137]	[0.424]	[0.403]	[0.147]	[0.136]
ln Importer's GDP	-0.238	-0.254	-0.415	-0.392	-0.237	-0.267
	[0.277]	[0.270]	[0.550]	[0.491]	[0.279]	[0.272]
ln Exporter's GDP	1.708***	1.589***	3.523***	2.706***	1.671***	1.554***
	[0.370]	[0.361]	[0.913]	[0.722]	[0.374]	[0.360]
ln (1.E-06+Importer's cases)	0.000		-0.003		0.000	
	[0.002]		[0.004]		[0.002]	
ln (1.E-06+Exporter's cases)	-0.012***		-0.025***		-0.011***	
	[0.003]		[0.007]		[0.003]	
ln (1.E-06+Supplier's cases)	-0.047**		-0.212***		-0.050***	
	[0.018]		[0.072]		[0.019]	
ln (1.E-06+Importer's deaths)		0.000		0.000		0.000
		[0.002]		[0.004]		[0.002]
ln (1.E-06+Exporter's deaths)		-0.014***		-0.025***		-0.015***
		[0.004]		[0.007]		[0.004]
ln (1.E-06+Supplier's deaths)		-0.071***		-0.338***		-0.068***
		[0.020]		[0.048]		[0.019]
Trade period	Jan-Jun	Jan-Jun	Jun	Jun	Jan-Jun	Jan-Jun
Covid period	Jan-Jun	Jan-Jun	Jan-Jun	Jan-Jun	Jan-May	Jan-May
Number of observations	8,382	8,382	7,662	7,662	8,382	8,382
Log pseudolikelihood	-2E+10	-2E+10	-1E+10	-1E+10	-2E+10	-2E+10

Notes: This table reports the estimation results by the PPML method. ***, **, and * indicate 1%, 5%, and 10% levels of statistical significance, respectively. The standard errors reported in parentheses are those clustered by country pairs. In all specifications, we control for country-pair fixed effects and time fixed effects.